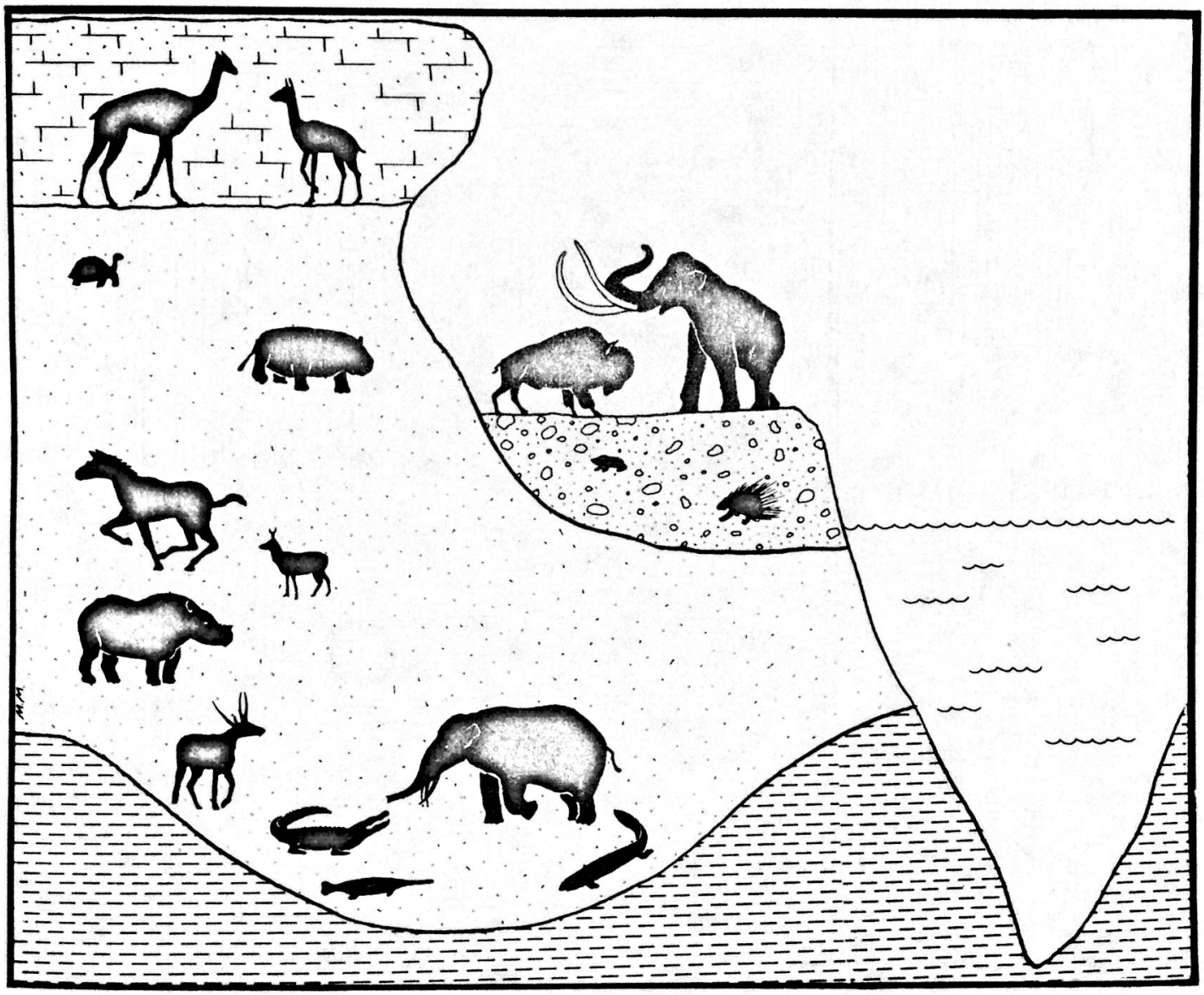
Brown Klaugus

VERTEBRATE PALEONTOLOGY
OF THE PROPOSED
NORDEN RESERVOIR AREA
BROWN, CHERRY, AND KEYA PAHA COUNTIES
NEBRASKA

M. R. VOORHIES



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PREPATORY NOTE - 1988

In the five years since the final draft of this report was submitted for publication, a number of research papers dealing with the vertebrate paleontology of the Norden area have appeared in print. It has not been possible to integrate references to these into the text as they are cited here in an effort to bring the reader up to date. The new research falls into three broad categories: 1) geological studies on the stratigraphy of the central Niobrara valley, 2) systematic studies of Miocene vertebrates from the Valentine and Ash Hollow formations, and 3) studies of the late Quaternary biota of the Niobrara valley.

Geological Studies

By far the most important paper on the geological framework of the fossiliferous Cenozoic rock sequence in north central Nebraska is Skinner and Johnson's (1984) authoritative study which documents more than 100 years of paleontological exploration of the central Niobrara River valley. Precise geographic and stratigraphic data are provided for 98 significant fossil vertebrate localities, including 12 within the area covered by the present report. Two new stratigraphic units are named, one at the top of the Valentine-Ash Hollow sequence, one at the base. The "unnamed post-Cap Rock member" referred to in the present report (e.g., in the discussion of Serendipity Quarry, locality Rp 111) is now the Merritt Dam Member of the Ash Hollow Formation. The authors propose the name "Cornell Dam Member" for a predominantly fine-grained unit at the base of the Valentine Formation stratigraphically below the Crookston Bridge Member. As indicated in the general discussion of the Valentine Formation of this report, the present author is not fully convinced that the two latter members can be unambiguously distinguished on a lithologic basis within the Norden area (see, especially, the discussion of the Rosetta Stone locality, Rp 108, where lithologies characteristic of the two members appear to interfinger rather than being separated by an unconformity. Fossil localities cited within the Cornell Dam Member include Norden Bridge, Egelhoff, Carrot Top, and Achilles quarries. As evaluated by Skinner and Johnson (op. cit.: 250) these quarries constitute the Norden Fauna (new) which "represents late Barstovian (or earliest Valentinian)" time. In the terminology proposed in the present paper, the Norden Fauna is medial Barstovian, distinctly older than the late Barstovian faunas from stratigraphically higher parts of the Valentine Formation.

An important synthesis of Cenozoic stratigraphic relationships in western Nebraska (Swinehart et al., 1985) deals primarily with the region lying to the west of the present study area but has major implications for future work in the Niobrara valley. Voorhies (1987) briefly describes stratigraphic and geomorphologic relationships at Rose Niobrara National Wildlife Refuge a few miles west of the Norden area.

AREA DEFINITION

The Norden Reservoir area includes approximately 24,000 acres of the central Niobrara River valley in north-central Nebraska (fig. 1). The proposed dam axis is located approximately 18 miles northwest of Ainsworth, Nebraska. As planned, this rolled earth-fill structure will impound more than 411,000 acre-feet of water with a surface area of 6,300 acres. The reservoir will extend from 100° west longitude to 100° 25' west longitude, a linear distance of 20 miles, creating more than 70 miles of lake shoreline.

In addition, more than 1,600 acres (648 ha) of land north of the dam axis will be disturbed to obtain earth fill for dam construction. Smaller areas adjacent to the dam including fishing pools, spillway, roads, and public access areas will also be directly affected by the project. Additional project features are to include a fish hatchery (to be located within the upper reaches of Fairfield Creek), the Smith Falls public access area, and modification of the Johnstown-Norden road.

In-field determination of all project boundaries followed maps and other guidelines provided by the Bureau of Reclamation.

REPORT ORGANIZATION

Following this introduction, the main body of this report is divided into two major sections. First, an overview of past and present paleontological investigations, including an assessment and recommendations, is presented. Secondly, in Appendix A, narrative descriptions of all known sites, and the fossils obtained from them during testing, are provided.

A separately-bound volume contains precise locational data and detailed records of all site-specific investigations. The latter include survey, excavation, photographic, and specimen inventories presented on standardized site forms. Original field records are on file in the archives of the University of Nebraska State Museum.

BACKGROUND

PREVIOUS STUDIES

General

The Niobrara River valley has been known for more than a century as a major source of vertebrate remains of late Cenozoic age. Some fossil accumulations in the Niobrara drainage basin are so spectacular that they have attracted considerable attention from the general public. The famous Agate Springs Fossil Quarries (now Agate Fossil Beds National Monument) lie near the headwaters of the Niobrara in Sioux County,

western Nebraska (U.S. Dept. of the Interior, 1980). An equally unusual occurrence of Miocene vertebrate skeletons, in a volcanic ash bed, has recently been reported from the lower reaches of the Niobrara valley, in Antelope County (Voorhies, 1981).

Although less well-known, there are literally hundreds of other fossil vertebrate deposits of equal or greater scientific importance in the central Niobrara valley. Useful summaries of paleontological work in north-central Nebraska are provided by Skinner et al. (1968), Webb (1969a), and MacGinitie (1962).

As long ago as 1796 Scots explorer James Mackay found "the middle part of the thigh bone of an animal the large end of which was 7 inches in diameter and the other 6 ¼ inches" near the confluence of the Keya Paha and Niobrara rivers (Diller, 1955: 126-128). A map attributed to Mackay by Nasatir (1952: opposite p. 110) shows "ossemens de mamouth" at this location (see also Stout, 1977: 117).

The first professional geologists and paleontologists to collect vertebrate fossils from the general region were apparently F.B. Meek and F.V. Hayden who discovered Miocene mammalian remains at the summit of the Bijou Hills about 40 miles north of the mouth of the Keya Paha River in 1853 (Skinner and Taylor, 1967).

It was not until 1858, however, that the existence of rich fossil beds along the Niobrara River became known. In that year Joseph Leidy published brief descriptions of specimens collected in 1857 by F.V. Hayden. The latter had served as geologist on the military expedition into the region between the Missouri River and the Black Hills under the command of Lt. G.K. Warren (see Skinner and Taylor, 1967: 45). Leidy's massive monograph on "The Extinct Mammalian Fauna of Dakota and Nebraska" was finally published in 1869. In it, 28 new species and 13 new genera and subgenera, most of them still recognized as valid today, were described and illustrated. Leidy, the founder of vertebrate paleontology in North America, at once realized the transitional character of the fossils from "the sands of the Niobrara" between the geologically more ancient mammals from the White River badlands and the younger, Quaternary fossils already known from eastern North America. (Henry Fairfield Osborn (1928: 155), far from the most modest of scientists, said of Leidy's 1869 paper: "That work still ranks in breadth and accuracy as the finest single contribution that has been made to vertebrate paleontology in this country, if not in the world.")

The first expedition to the Niobrara with the explicit intent of obtaining fossil vertebrates was organized by Yale's O.C. Marsh. In 1873, Marsh led the Yale Student Expedition on a collecting trip of the High Plains which included twelve days (June 26-July 7) exploring the Niobrara and its canyons between the mouths of Antelope and Minnechaduza Creeks (see expedition map in Schuchert and LeVene, 1940: 135). Among

the important fossils secured on this trip were carnivores later published by Thorpe (1922) but perhaps the most significant was the genoholotypic specimen of Pliohippus pernix (Marsh, 1874). In the latter paper, Marsh announced that the fossil record of the horse family in North America was far more complete than that in the Old World and that he now had an adequate series of specimens documenting the transition from unspecialized Eocene Orohippus to the highly specialized living genus Equus. This demonstration of an evolutionary sequence, the first for any vertebrate family, gained historical significance through its adoption by T.H. Huxley ("Darwin's bulldog") as one of the strongest possible arguments in favor of organic evolution. Rudwick (1972: 254) notes that Marsh's work on equid phylogeny "...symbolises appropriately the emergency of American palaeontology from its earlier quasi-colonial status into full intellectual maturity."

Marsh's great rival, E.D. Cope, apparently never worked on the Niobrara but did describe (Cope, 1890) several Miocene carnivore dentitions found near Fort Niobrara by a medical officer stationed at the fort.

An expedition from the American Museum of Natural History (AMNH) led by J.W. Gidley collected in the vicinity of Fort Niobrara in 1903. Some fossil horse material collected on this trip was described by Gidley (1906, 1907). In 1914 another Yale party, under the direction of R.S. Lull, retraced, in reverse, Marsh's Niobrara River route and made additional collections.

In the meantime, E.H. Barbour, director of the University of Nebraska State Museum (UNSM) had begun sending field parties into Brown, Cherry, and Keya Paha counties. UNSM expeditions worked in the Niobrara canyons annually between 1913 and 1917 and secured large numbers of vertebrate fossils, especially from two localities. At the first locality, near Valentine in Cherry County, J.B. Burnett and A.C. Whitford made what was probably the largest collection of North American Miocene horses known up to that time. The Valentine Railway Quarries (UNSM localities Cr 12, 13 and 114) as they are now called (see Skinner et al., 1968; Evander, n.d.) also yielded many other exceptionally well-preserved mammalian fossils, several of which were described in publications by Barbour and Cook (1917b) and Barbour (1925a). A second area of concentrated collecting by UNSM parties was north of Ainsworth, Brown County, in a short but deep tributary canyon of Dutch Creek called Devil's Gulch (Barbour, 1914b; Skinner et al., 1968). Unpublished field records of Burnett and Whitford, as well as C.H. Eaton, R.W. Ellis, C.J. Elmore, O.E. Hans, M.G. Richmond, and E.F. Schramm which are preserved in the UNSM archives provide documentation of the early collections.

By far the most intensive, continuous, and productive paleontological and geological exploration of the fossil beds in the central Niobrara valley began in 1926 when Morris F. Skinner spent the first of nearly

sixty field seasons collecting vertebrate fossils in the Ainsworth area. Skinner (along with his associates, the late J.H. Quinn, R.L. Mefferd, G.K. Fletcher, and others) assembled for the Frick Laboratory, AMNH, an unrivalled series of stratigraphically-controlled collections from north-central Nebraska. Only a fraction of the Frick collection from this area has been published upon (but see Frick, 1933, 1937; Skinner and Hibbard, 1972; Skinner and MacFadden, 1977; Woodburne et al., 1981; Rich, 1981; Baskin, 1982). Skinner and F.W. Johnson have submitted for publication a thorough documentation of the stratigraphic relationships of the Frick quarries (numbering nearly a hundred) in the Niobrara River valley (M.F. Skinner, personal communication, 1983).

Following an absence of more than a decade, UNSM field parties returned to north-central Nebraska in the years 1928 through 1935 (field books of A.L. Lugn, E.H. Colbert, P.O. McGrew, L.H. Luckert, R.C. Harper, F.W. Johnson, G.E. Meade, C.S. Osborn, D.A. Franzen, K.L. Rathbun, and T.M. Stout in the UNSM archives). Many superb specimens, including proboscideans described in papers by Barbour (1931, 1932, 1934), were collected. Among the notable collections made for UNSM were the following: 1) F.W. Johnson's series of merycodont skulls and other remains from Crookston Bridge Quarry on the Niobrara River (UNSM Cr 15, see Skinner et al., 1968, plate 22; Frick, 1937). 2) McGrew and Harper's collection of ungulate and carnivore specimens from the newly-reopened Valentine Railway Quarry A (UNSM Cr 12). 3) Collections from Gordon Creek Quarry (first by Lugn and Colbert, who discovered the site in 1928, later by McGrew and others). 4) A sample from Burge Quarry on the Snake River (found by McGrew in 1932, later worked by parties from UNSM, the University of California and the Frick Laboratory). Most recently, in 1977, R.L. Evander collected fossils at Valentine Railway Quarry "B" (Cr 13) in connection with his stratigraphic studies of the Railway quarries (Evander, n.d.).

The University of California assembled significant collections in Cherry County in 1933 through 1936 under the leadership of R.A. Stirton. The California collections from Burge and Gordon Creek quarries, along with those from higher and lower stratigraphic levels on the Fort Niobrara National Wildlife Refuge east of Valentine, were used by Stirton and McGrew (1935) as the basis for recognizing three district faunal or biostratigraphic subdivisions of the Tertiary in the Valentine area. S.D. Webb enlarged the University of California collections from Fort Niobrara during the 1962 field season. Webb's work culminated in his publication on "The Burge and Minnechaduza Clarendonian mammalian faunas of north-central Nebraska" (Webb, 1969a). This important study remains the only monographic treatment of any of the large faunal samples from the area to have appeared since Leidy's day.

Published references to fossils collected from the tri-county area dealt with here number in the hundreds. A representative sample of these is listed in tables 1 and 2. The latter is intended to be a complete list

of named vertebrate taxa for which the type specimens certainly or probably (in the case of the Hayden-Leidy fauna) were collected from the Niobrara River drainage system in Brown, Cherry, or Keya Paha County.

Although not so rich in fossil plants as in fossil vertebrates, late Cenozoic strata in north-central Nebraska have yielded some important paleobotanical specimens. Most significant is the Kilgore Flora collected from the lower Valentine Formation in Cherry County (MacGinitie, 1962). Twenty-four genera of plant megafossils and 17 of microfossils from this site provide the most detailed available picture of Miocene vegetation and paleoclimatic conditions for any location on the Great Plains. A smaller fossil leaf flora from the Valentine Formation was described by Chaney and Elias (1936) from the White Cliffs locality, Plum Creek, Brown County. The occurrence of abundant hackberry (Celtis) seeds in the Tertiary rocks near Valentine was noted by Barbour (1925b). Elias (1935, 1942) in his monumental study of silicified grass and borage remains from the Great Plains Tertiary dealt with a number of Brown and Cherry County samples.

Fossil wood is relatively common in the Valentine Formation, both as upright stumps and water-rolled logs, but it has been virtually unstudied until recently. Work in progress by J. Landon and M. Bolick (UNSM) promises to provide a new tool for quantitative paleoecological analysis of Miocene environments. Andrews (1970) has described a diverse diatom flora from the Valentine Formation.

Within the Norden area

The only written documentation of paleontological work in the Norden area during the first two decades of the twentieth century is in the 1913 field notes of A.C. Whitford, one of Barbour's earliest and ablest collectors. Whitford (n.d.: 109-114) records a five-day geological and paleontological reconnaissance of Fairfield Creek (Brown Co.) made on September 22-26 of that year. He found a number of Miocene fossils but reported that "they were in a very fragmentary condition." A.L. Lugn and E.H. Colbert also collected briefly on Fairfield Creek for UNSM in 1928 (n.d. UNSM archives). Morris Skinner and the late J.H. Quinn began collecting on Fairfield Creek in 1928 (M.F. Skinner, pers. comm.) and found a number of excellent specimens, some of which have been published (gomphotheres by Frick, 1933: 596, 597, 600, 618; oreodonts by Schultz and Falkenbach, 1941: 20, 26; dromomerycids and antilocaprids by Frick, 1937: 89, 329, 366, 423, 466, 486). No detailed geographic or stratigraphic information has yet been published concerning the F:AM Fairfield Creek collections but such will be presented in a forthcoming publication by M.F. Skinner and F.W. Johnson.

The diverse and abundant remains of "microvertebrates", especially amphibians and reptiles, in Niobrara valley rocks remained largely unstudied until the 1960's. Research on this neglected aspect of the

fauna was initiated by J.A. Tihen of Notre Dame University who excavated and sieved several tons of fossiliferous basal Valentine sediments at Norden Bridge Quarry in 1962 and 1963. Norden Bridge Quarry had been discovered by M.F. Skinner in 1929 and worked periodically for larger vertebrates since then. Its potential as a source of small vertebrates was not recognized, however, until 1960 when a large tortoise shell from the site (Hibbard, 1960) was found to contain an abundance of fish, amphibian, and reptilian remains. A party from the University of Michigan (UMMP) worked at the site in 1964 as did parties from Michigan State University (MSU) from 1971 through 1976. J.A. Holman of the latter institution is chiefly responsible for bringing the strikingly diverse lower vertebrate fauna of Norden Bridge Quarry to the attention of the scientific public.

Egelhoff Quarry, on the opposite side of the Niobrara River from Norden Bridge Quarry, was discovered by Morris Skinner in 1964. The first extensive collections at the site were made by Skinner and C.W. Hibbard (UMMP) in June, 1967. Additional collections were made by UMMP field parties late in 1967 and again in 1968. In 1971, J.A. Holman processed 35 tons of fossiliferous matrix from the quarry and an additional seven tons in 1974. C. Chantell (1971) identified the amphibians from the site. Holman (1973b) described the reptiles, including three new species of snakes.

A new site, Kuhre Quarry, was discovered by Holman in 1971 several miles west of Norden Bridge Quarry. By sieving two tons of matrix, Holman's Michigan State University team recovered the remains of three species of fishes, a frog, three species of turtles, plus carnivore, horse, camel, and proboscidean remains (Holman, 1977a).

A summary of paleontological sites previously known from the study area is provided in Table 3. Among them these sites have produced 21 new species of Miocene vertebrates (Table 2), 18 of which are in current use (Table 4).

STRATIGRAPHY

The study area occupies a deeply-incised portion of the Niobrara River Valley at the northern margin of the Nebraska Sandhills, a stabilized dunefield of late Quaternary age (Ahlbrandt and Fryberger, 1980). The area lies approximately 80 miles west of the Pleistocene till border which crosses the Niobrara a few miles above its mouth (Flint, 1955: plate 3).

Tertiary strata of primarily fluvial origin are comparatively well-exposed along the Niobrara River in north-central Nebraska but few detailed stratigraphic studies have been made except by vertebrate paleontologists attempting to document their finds. The stratigraphic succession in the Valentine vicinity has been studied by Johnson (1936,

enclosing the fossils provided the critical proof of integrity in all cases. Also important is the lack of evidence of modern disturbance (e.g., contamination by surface debris, interruption of stratification by animal burrows).

Significance, for present purposes, equates with "scientific importance", an admittedly subjective concept, but one for which the following operational guidelines are proposed. A "significant" paleontological site is (1) one at which at least one professional paleontologist has devoted sufficient time and resources to collect fossils, curate them in a permanent museum collection, and publish upon them at least one scientific paper in a major (refereed) journal, or (2) newly identified sites with a demonstrated potential of producing fossils equalling or exceeding in "research quality" those currently forming the basis for professional work in paleontology. The standard of "research quality" against which the Norden samples were judged in the present study consists of late Cenozoic terrestrial vertebrate fossils described and discussed during the past ten years in a selection of national and international journals and museum series available in the University of Nebraska libraries. Periodicals consulted include: the Journal of Paleontology, Journal of Vertebrate Paleontology, Paleobiology, Palaeontology, Geobios, Palaontologische Zeitschrift, Journal of Mammalogy, Copeia, Herpetologica, and approximately fifty others.

Detailed assessments of each of the 35 identified paleontological sites in the Norden area are provided in Appendix A below. All sites except one possess "integrity" as defined above. The exception (site Bw 116) originally had integrity but lost it when the only known identifiable fossil on the premises, a mammoth tooth, was collected. The site still retains "significance", however, as the source of a biostratigraphically-diagnostic specimen useful in deciphering the geomorphological history of the Niobrara River. An assessment of the research potential of the other sites will be presented following a discussion of the role played by Niobrara Valley fossils in general paleontological studies.

A major goal of paleontology is to understand the history of life on Earth. Although most detailed paleontological studies are necessarily limited to short time intervals and to geographic areas with boundaries measured in a few tens of meters or kilometers, data accumulated from a large number of such analyses lead to an increasingly detailed reconstruction of the three-billion-year history of our planet's past and present biota. There are two major emphases in paleontological research; firstly, an unravelling of the lines of descent (phylogeny) of individual kinds of organisms, and secondly, an elucidation of changes in the organic/inorganic millieu in which phylogeny occurred (Paleoecology). Although the Darwinian concept of organic evolution could have been (and indeed was) developed in the absence of an adequate fossil record for even a single lineage, fossils provide the only concrete evi-

dence of the actual course taken by evolution. Useful phylogenies can be worked out by other means (e.g., the systematic methodology of Hennig, 1966) but they remain to some degree hypothetical if unsupported by paleontological documentation. For all its imperfections (Raup and Stanley, 1978:1-26), only the fossil record shows what really happened in the geologic past.

The paleontological resources of the Central Great Plains, especially northern Nebraska, are of far more than routine interest. Although they provide a detailed record for only the most recent one-half of one percent of the 4500 million years which have elapsed since the formation of the Earth's crust, their coverage of that interval, the later third of the Age of Mammals, is remarkably good. In their comprehensive review of the current status of knowledge about fossil mammalian faunas worldwide, Savage and Russell (1983: 295) state that "...the area of northern and northwestern Nebraska is especially noteworthy for its demonstration of the entire succession of land-mammal ages for the Oligocene through Miocene of North America on an extended, regional scale...Nebraska's faunal representation of these ages, collectively, is unrivalled."

Vertebrate paleontologists consider the Niobrara Valley important not merely because of the great abundance of museum-quality specimens to be collected there but because the fossils occur in a series of tectonically-undeformed, superposed strata spanning a significant fraction of Miocene time. Those in the central portion of the Valley, in and near the Norden area, provide especially complete coverage for the interval between approximately 14 million and 9 million years before the present (MacFadden et al., 1981). Strata of Barstovian and Clarendonian age exposed along the Niobrara River and its tributaries in Cherry, Brown, and Keya Paha counties have yielded a substantial fraction of the fossil specimens upon which our knowledge of the evolution of horses, camels, prongbucks, and many other characteristic Great Plains mammals is based. As a concrete example of the importance of the central Niobrara valley in furnishing critical research specimens of Barstovian and Clarendonian age mammals, one may cite the fact that 25 of 28 skeletons of these ages sufficiently complete to be used by Hussain (1975) in his study of the functional anatomy of the pelvic limb in fossil horses were collected from the Valentine and Ash Hollow formations in Brown and Cherry counties, Nebraska.

Because of the relatively-precise time controls (both biostratigraphic and radiometric) available on Miocene fossils from this relatively small area, the latter serve the scientific community as benchmarks in stratigraphic, evolutionary, and paleoecological studies. (Numerous examples of the former two categories are cited in Table 1. Synthetic paleoecological research on Cenozoic terrestrial communities is still in its infancy but several studies focusing on the nature of the transition from mostly-forested to mostly-grassland habitats in the Great Plains, have appeared (MacGinitie, 1962; Gregory, 1971; Webb, 1977).)